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Taxonomy as the Organization of Knowledge

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The goal of taxonomy is the same as that of classification among the sciences in general: the organization of knowledge. Such knowledge is the intellectual content of the science and should not be confused with the organization of tools used in work. The new philosophy of systematics that emerged in the second half of the twentieth century clearly distinguishes between groups that are concrete particular things, or individuals in a broad ontological sense, and those groups that are kinds of things, or classes. In modern taxonomy the taxa such as *Homo sapiens* and *Homo* are individuals, and the categories such as the species and the genus are kinds, or classes. The laws of nature refer only to classes, not individuals and for that reason the categories but not the taxa can be considered natural kinds. Taxa having the same rank are equivalent insofar as they play the same role in nature and in evolutionary theory because they participate in the same processes and the same laws of nature apply to them. Species are fundamentally different from higher taxa because above the species level cohesion is lacking and the units are purely historical entities. Species are fundamentally different from lower taxa because below the species level cohesive capacity still exists. Asexual clones are likewise not cohesive and should not be confused with species and lower taxa. The kind of pluralism that allows the coexistence of a diversity of species concepts creates confusion by using the same term for fundamentally different kinds of objects, impedes the unification of knowledge, and turns taxonomy and its branches into parochial disciplines that offer little of anything of interest to science and intellectual culture in general.

Systematics, or systematic biology, has commonly been defined as the science of organic diversity, and taxonomy as the branch of systematics that deals with its more formal aspects, especially classification schemes and nomenclature. Classification and naming of course are by no means limited to biology, or even to the sciences. They are fundamental to language and thinking in general. This discussion studiously ignores such semantic niceties as whether a system in which the elements are individuals rather than classes should be considered a classification (Griffiths 1974; O'Hara 1993). Let us rather focus on the things rather than the terms. A proper understanding of classification in general and taxonomy in particular is better gained by considering its function in the life of the mind.

My earlier thoughts on such matters suggest that the goal of classification in biology is the same as it is in all sciences: the organization of knowledge (Ghiselin 1997:17, 24, 300). Scientific knowledge has to do with the intellectual aspects of our lives — with causes, theories, history and the laws of nature. We scientists organize our knowledge in order that we can think, and indeed if it were not organized it would not be knowledge. We also organize other things, such as laboratories, expeditions, and museums. It does not seem a good idea to treat a grocery store as a model for how scientists ought to classify or to use such an arrangement of goods as an argument in favor of classification on the basis of similarity as suggested by Mayr and Bock (2002). Yeast in a grocery store is not put next to mushrooms, whether fresh, canned, or frozen, and roses are not close to strawberries. When doing research, I avoid paraphyletic taxa altogether, but I find them perfectly innocuous when filing my reprints.

There is an important difference between the organization of work and the organization of knowledge, even when the work is organized so as to further the acquisition of knowledge. Confusion between the two has had some unfortunate consequences, especially with respect to the "practical" aspects of taxonomy. Mayr (1998:9722) gets his priorities wrong when he asserts:

> A classification is an information storage and retrieval system. Its aim is to permit you to locate an item with a minimum of effort and loss of time.

Of course, classifications are useful for that very reason, but there is a profound difference between knowledge and information. A scientist knows a great deal, whereas a telephone book knows nothing whatsoever. Scientific classification therefore must not be treated as if it were just epistemological gadgetry. It tells us what kinds of things we are dealing with, and therefore it is an ontological affair. Science is about the things and kinds of things that play a role in scientific laws and theories, and that is what gives meaning to its classifications.

Our ontology, in other words, our conception of what things are, and therefore of what is responsible for their properties, has evolved, together with the rest of science, profoundly affecting our conception of how we ought to classify. Biological classification was revolutionized in the nineteenth century when the natural system that had been codified by Linnaeus was reinterpreted in evolutionary terms by Darwin. It was revolutionized again in the second half of the twentieth century when the philosophy of the subject finally caught up with its practice. The traditional answers had to be rejected because they had addressed the wrong questions. By the dawn of the present century there had emerged what I have called the "biological consensus" and the "philosophical consensus" with respect to species concepts (Ghiselin 2002). By "consensus", I do not mean to imply that the views in question are uncontroversial, but rather that they are the majority view and there is no satisfactory alternative to either of them. By the biological consensus, I mean that species are the most incorporative populations that participate in evolutionary processes. By the philosophical consensus I mean that species are not classes or kinds of organisms (or of anything else), but rather individuals at a higher level of integration, the component organisms of which are their parts, not their members. In logical terminology this implies that the taxonomic category of the species is a kind, the members of which are individual species (in other words species-level taxa).

The "individuality thesis," which is the core of the philosophical consensus became a serious topic of debate among biologists and philosophers around the time that I finally managed to get it taken seriously (Ghiselin 1974; Hull 1976). A remarkable variety of objections to it have appeared. The arguments have been laid out in great detail in my recent book (Ghiselin 1997). Therein I answered all of the objections to it that had appeared in print up to the time the book was written. I see nothing in subsequent publications that presents a viable alternative. But efforts go on apace and there is room for some further commentary. One topic of interest has been the possibility that species are natural kinds. I reject that view, but the notion of natural kinds provides a basis for an argument against what is called "pluralism" with respect to species concepts. This argument has been sketched out earlier (Ghiselin 2002), but only briefly.

Perhaps the best way to explicate the individuality thesis is by reference to a scheme of the familiar Linnaean Hierarchy with its groups and levels:

Classes :	*Individuals*
Phylum :	Chordata, Mollusca, etc.
Genus :	*Homo*, etc.
Species :	*Homo sapiens*, etc.
Organism:	Charles Darwin, Fido, etc.
Cell :	etc.
Molecule :	etc.
Atom :	etc.

Actually the levels from the organism downward are not part of the formal taxonomic scheme, but that is irrelevant for my point. To say that *Homo sapiens* is a species is equivalent, at a lower level, to saying that Charles Darwin was an organism. The individuals (on the right) have parts at lower levels, unlike the classes (on the left). Sorting out the classes and individuals in this way makes it easier to explain certain important points. A species concept or definition is a definition of the name of a class ("species") not a definition of an individual that is an instance, specimen or example of the class of species (such as "*Homo sapiens*"). By analogy, an organism definition is a definition of "organism" not of Charles Darwin.

Maybe this is not clear enough, so let us take a brief look at some political individuals classified in the same manner:

Classes :	*Individuals*
National/State:	Canada, Mexico, etc.
Province :	Ontario, British Columbia, etc.
County :	Ontario County, York County, etc.
City :	Ontario, Toronto, etc.
Citizen :	Janet Landa, etc.

Didactically, this analogy has often proved quite useful. Obviously, Ontario is a province and not a National State. Also, Ontario is a part of Canada, not a Canada. Janet Landa, although a Canadian, is not a Canada either. By the same token she is a part of *Homo sapiens*, rather than a *Homo sapiens*, whatever that is supposed to mean. Now consider why is it that we rank entities at the same level. For the citizen that is more or less obvious: each functions the same way and that is even true from one national state to another. It is a bit less obvious why Canada is equivalent to much smaller and less populous national states, such as Luxembourg. The answer is their sovereignty. More problematic is the equivalence between the subunits of various national states, for example, between Manitoba and Rhode Island. Here again we have an important point: the categories may give just quantitative rather than qualitative distinctions. There are serious alignment problems here.

Crudely speaking, a natural kind is a class the membership of which is determined by laws of nature (Quine 1974, 1979). A good example would be the various chemical elements. Supposedly a piece of metal is gold because it has the atomic number 79 and other important properties that make it gold rather than lead. Natural kind theory can be understood as an effort to ground classification in causality (etiologically, see Ghiselin 1997, pp. 74, 191), and in that respect it resembles efforts by modern taxonomists to create natural systems, although the underlying causes differ profoundly. Scientific investigation would then aim to discover the underlying causal basis of groups that are already to some degree known, but not fully understood. Accordingly, the laws are often conceived of as essences, or something close to essences. That makes sense if we understand what natural kind theory was supposed to accomplish with respect to definition (Kripke 1977, 1980). It meant that one could define, or fix the reference, of the name of a class through a so-called ostensive definition, without having to provide defining properties. That made the definition of the names of classes very much like that of the names of individuals. We point at the single thing to be named, and that fixes the reference of the name.

An appreciation of the fact that species and lineages are individuals has given rise to much fruitful discussion on how to "define" the names of taxa by stating which lineages it is to which the names refer, and without pretending that such taxa have defining characters (De Queiroz and Gauthier 1990, 1992, 1994; De Queiroz 1994). The suggestion that the names of species must be defined ostensively was one of the first important implications of the individuality thesis for the practice of taxonomy (Ghiselin 1966:209). It clarified the role of nomenclatorial types. The PhyloCode, a further development of that line of reasoning, is something for which I am happy to accept some of the blame but not the credit! Ostensive definition works very well for individuals, including species and lineages of higher rank, but it runs into serious difficulties when we try to apply it to classes. Until the laws that supply the causal basis are known, the natural kind term has to be a "something, I know not what." And once we have discovered what the laws are, we can replace the ostensive definition with one cast in terms of defining properties.

However, the idea that the classes of interest to scientists are the ones that owe their important properties to laws of nature remains attractive. Pre-Darwinian biologists widely believed that taxonomic groups are manifestations of as yet unknown laws of nature. Darwin, however, showed that they are purely historical entities, the products of contingency, not of nomic necessity (as such conformity to law is called). That makes an enormous difference. Laws of nature make no reference to any one individual but rather are about classes, which are spatio-temporally unrestricted. So to make species and other taxa into natural kinds one would have to deny that they have a beginning or an end, a particular location, and much else besides. Given that species are individuals, then the laws of nature would have to be about classes of species, such as big species or inbred species. I have at least come up with some examples of laws for classes of species. Some authors have claimed that species are indeed classes and have asserted that they do have laws (Mahner and Bunge 1997; Bock 2000). No example of such a law has been provided. Don't hold your breath.

Species are not classes of organisms. However, like multicellular organisms, they are individuals with somewhat homogeneous components. That homogeneity is one obvious reason why species are so often mistaken for classes. It also has made it easier for philosophers to perpetuate the delusion. The laws of nature are predictive, if only on a statistical basis and with all sorts of qualifications. One might claim that certain properties of the components of a taxon can be extrapolated to other pseudo-instances of that taxon. Of course one can, much as with an individual organism and its components, or with its ontogenetic stages. One can characterize a species by its chromosome number, and there is even less chromosomal variation within an organism. Likewise a person's personality, although it may change with the passage of time, is usually stable enough that we can forecast some kinds of behavior. When systematists are studying phylogenetics they try to find so-called "conservative characters," which are parts that evolve slowly and therefore are more reliably extrapolated across time and genealogy. But such extrapolation, to the extent that it is based on laws of nature at all, is not based upon laws of nature that refer to any of those individuals. The notion that biological classification is "predictive" has some justification, but only in the sense that familiarity with somebody's personality allows one to "predict" his behavior.

The notion that species are natural kinds is hardly new (Kitts and Kitts 1979). The arguments against it are well known (Hull 1981). Its latest manifestation takes the form of asserting that species are "homeostatic cluster natural kinds" (Boyd 1991, 1999; Griffiths 1997, 1999; Keller et al. 2003). Calling species natural is unobjectionable. Species are natural objects, not something that has been created through human artifice. Natural classification remains natural classification irrespective of whether the groups are classes or individuals. However, "homeostatic" is a bad metaphor. If something is to have homeostasis in the literal sense it has be an individual, such as a thermostatically controlled heating system or a homeothermic organism. Boyd argues that species possess something like homeostasis, and they do, but that is because they are individuals not kinds. To say that species are kinds is simply a category mistake. They do not function as kinds in evolutionary theory (Coleman and Wiley 2001) and that is all that matters. Consider two metaphysical taxonomies:

I.
That which is not natural
  Artificial kinds
  Supernatural kinds
That which is natural
  Natural kinds that are kinds
  Natural kinds that are not kinds

II.
Individuals
Kinds
  Natural kinds
  Artificial kinds

The former classification is what we get when we conjoin bad metaphysics with bad nomenclature. Rather than belabor such points, however, the goal here is to turn the argument on its head, and rebut those authors who claim that species are natural kinds and who on that basis argue that we should adopt a kind of pluralism with respect to species concepts.

With respect to natural kinds, my argument is as follows. The biological species (category) is a natural kind. It has laws of nature that apply to those individuals that are its members. It is, however, one of many levels in the hierarchy. Other levels are different kinds, and different laws of nature apply to their members. This is because the individuals at the various levels participate in different processes. Not surprisingly, they play different roles in evolutionary theory. If we pass upward in the scheme of the Linnaean hierarchy sketched out above we can easily see that the individuals at each level engage in somewhat different processes, though some processes do go on at more than one level. Atoms form covalent bonds; cells undergo cell division; organisms copulate; and species speciate. Note that above the species level, something very important happens, or ceases to happen. Cohesion ceases to exist, and we get purely historical entities that do not participate in processes at all. Matters may be a little more complicated, but the basic point remains. At that level there is a fundamental discontinuity in the causal nexus. This is appreciated in the theoretical literature. Gould (2002), who belabored the individuality thesis at great length, came to recognize that species selection will not work above the species level. At populational levels below the species analogous processes do go on, but obviously not among pseudospecies for these, being asexual, do not consist of cohesive populations. Wiley (1978) even suggested that noncohesive individuals are not individuals at all. I, on the other hand, have always argued that such a move does not make quite the proper ontological cut in metaphysical taxonomy (Ghiselin 1981, 1997). In other words, instead of:

Classes
Individuals
Historical entities

I prefer:

Classes
Individuals
Cohesive individuals
Historical entities

I refer to an "ontological cut" as a deliberate allusion to Plato's metaphor of cutting nature at her joints (see his dialogue *Phaedrus*). In metaphysics, as in any other natural science, the goal of classification is to arrange the materials in terms of their fundamental relationships one with another. The distinction between classes and individuals is arguably the most fundamental that one can make. Those individuals which are, and those which are not, cohesive, nonetheless share a residuum of very important properties that classes lack: they have a beginning and an end; there are no laws of nature for them, etc. But the two kinds of individuals are indeed fundamentally different in a very important way, and that difference is profoundly significant for how we ought to classify. Once a species has speciated, it becomes a purely historical entity, and like all purely historical entities it is no longer capable of participating in processes, in other words of doing anything. Exactly the same is true of clones and other entities that have lost their former cohesion. The reason why the species category is so important, and so profoundly different from other taxonomic categories, is that above the species level the individuals play a profoundly different role in nature and in our ways of thinking about it. And by the same token there is no excuse for classifying in a way that does not underscore the distinction between species and pseudospecies. Asexual species are a contradiction in terms in every context in which the species concept plays a role in evolutionary theory. In this connection, I should mention that there has been a great deal of misconception and outright mythology about bacteria. If bacteria do not have sex, why did Joshua Lederberg get the Nobel Prize for discovering it? And why has molecular research so clearly shown it to be rampant among them? The problem that bacterial sex poses for speciation theory is not that it does not exist, but rather that it may not be so effective a cohesive force as it is among eukaryotes and, therefore, not limit diversification to such a great extent (see Dykhuizen, this volume, p. 54).

Likewise, the populational components of species differ from entire species in a fundamental way. Therefore, they play a different role in evolutionary theory, albeit not for the reason that species differ from higher taxa. If parts of species that have been separated geographically for a time come back together they fuse back into a single population, owing to the forces of cohesion. In evolutionary theory, allopatric populations that are not yet reproductively isolated function only as incipient species. It is unfortunate that the question of what qualifies as a species has been cast in terms of the amount of gene flow. For that reason as well, it is sometimes wrongly assumed that there can be no gene flow at all. Provided that gene flow does not suffice to make the populations in question fuse back into a single unit and prevent them from diverging indefinitely, they are separate species. (For a detailed exposition, see Ghiselin 1977:99–102).

Of course, parts of species, and parts of organisms are important, but nobody has ever provided a legitimate reason for calling them species. I emphasize this point because certain pluralist philosophers have alleged that there are certain contexts in which it is more appropriate to use a species concept other than the biological one (most recently Reydon 2003 and Brogaard 2004). So far as I can tell, this allegation is nothing more than a figment of their imaginations or an expression of hope. I can give plenty of examples where confusing species with other things has had a detrimental effect on biological research, and when not doing so has had a beneficial effect, sometimes saving countless human lives. The value of distinguishing among the various cryptic species of mosquitoes, some of which serve as vectors of malaria and some of which do not, is a particularly well known example of the latter. But I can think of not a single case for which our study of those other things would be in any way ameliorated by calling them species rather than something else. Maybe somebody else can think of one. However, it seems to me that unless the pluralists can come up with some good examples that the rest of us can examine critically, we ought not to take them seriously.

The reason for having the units of evolutionary history correspond to those that are used in the study of evolutionary mechanisms may not be intuitively obvious to everybody. Although there are no laws of nature for individuals, there are laws of nature for kinds of individuals. Prior to the emergence of the new philosophy of systematics it was widely maintained that there are no laws of nature in biology, and that, therefore, biology is somehow an inferior kind of science. It turns out that biology has its laws of nature, but these are laws for kinds of species, and for other kinds of individuals. As effective population size goes down, the frequency of loss of alleles by drift goes up, for example. Such laws have long been implicit in evolutionary biology, but they were overlooked because nobody knew where to look for them. Biology, like astronomy, is about both history and the laws of nature. In both sciences, our classification systems need to be organized in such a manner that the two can be put together. Data, including historical data, about particular things are used to test hypotheses that involve laws about things in the abstract. And laws are used to explain and to predict the behavior of the things to which they refer. We can begin if we wish with the Big Bang and provide a scientific narrative account of the formation of galaxies, stars, planets, and life with all its components.

We can see why it is not so good an idea to have a species concept, or, if you prefer, a definition of the species category, such that it conflates species with parts of species. In organizing our knowledge, we want to keep entities that play different roles both in nature itself and in our thinking about it conceptually distinct. We do not want to confound an organism with one of its component organs, or an atom with a subatomic particle. However, we do want to arrange the materials in our classification so that the individuals to which the same laws of nature apply are members of the same natural kind. That means that a species should be precisely the same kind of thing whether we are doing taxonomy, ecology, or genetics. Of course, a given process may occur, and the same laws of nature may apply, at more than one level. There are processes and relevant laws of nature that apply to populations generally, including parts of species as well as entire species: natural selection, sexual selection, genetic drift, to list but a few. We should also note that an individual can be a member of more than one level in a hierarchy, for example, a unicellular organism. In theory, a species might consist of just one self-fertilizing organism, and conceivably that organism might be the common ancestor of two species isolated by virtue of different chromosome numbers. That, however, would not contradict the proposition that it is species, not organisms, that speciate.

Species don't just speciate. They become extinct. And they also resist extinction. Why should we treat species as particularly important units when we aim to conserve biodiversity? The individuality of species helps to make some of the considerations more explicit. Although species are not organisms, they are like organisms in some important respects. When a species becomes extinct it is lost forever, and in that respect extinction is just like the death of an organism. How about the extinction of a part of a species? There is some analogy with the destruction of a part of an organism. A lost organ can be replaced through regeneration, and something like that can happen within species through migration and genetical recombination. In other words, a species has an ability to resist extinction over and above that of its component subpopulations.

For effective interdisciplinary work, the various systems need to be compatible with one another. One cannot carry out an effectual research program in comparative biology if the things being compared are not equivalent. Paleontologists devoted a great deal of effort to counting numbers of families and other taxa of higher categorical rank in the fossil record, but in the absence of a genus concept there is a serious question as to what, if anything, was being quantified. In principle, there is no such problem of commensurability in studies of biodiversity at the species level. However, the species concept has to be properly applied. In certain taxa, especially marine ones, a failure to recognize cryptic species has led to an underestimation of the number of species by a factor of ten (Knowlton 1993, 2000). The result has been a serious misunderstanding of both the generalities and the particulars of speciation, and not just inaccurate estimates of biodiversity. If the so-called species have to be morphologically distinct and easily told apart, then we get the impression that speciation involves a kind of saltation, or that we have before us a legitimate example of speciation in sympatry, or perhaps that the genus that we are studying is a very diverse species.

Just as taxonomists revise their classifications as a greater sample of biodiversity accumulates, so too do they reconsider the fundamental principles on the basis of which they classify. The notion that classification is based on similarity is an epistemological myth, and one that could only be corrected by ontological considerations. It was evolutionary theory, with its historical ontology, that led Darwin to reject that notion altogether and insist that classification be strictly genealogical. It was likewise ontological considerations that led Dobzhansky and his contemporaries to bring species level taxonomy into harmony with the genetics of natural populations. Finding a theoretical and philosophical basis for coordinating the basic units of taxonomy with those of other branches of biology, and with those of other sciences as well, seems a promising way to carry on in that grand tradition. Given past success and present prospects, the future of taxonomy looks bright indeed.

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